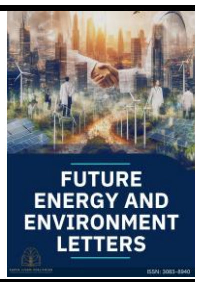
Future Energy and Environment Letters

Journal homepage:
https://karyailham.com.my/journals/index.php/feel/index
ISSN: XXX-XXX



Prediction of Bifacial Photovoltaic Panel Performance using Temperature and Irradiance Data at Johor, Malaysia

Nur Syazani Sukimin[1,*], Ahmad Fateh Mohamad Nor[1,*], Nur Hanis Mohammad Radzi[1], Naji Ammar Mansor Eltawil[2]

[1] Department of Electrical Engineering, Faculty of Electrical and Electronic Engineering, Universiti Tun Hussein Onn Malaysia, Batu Pahat, Johor, Malaysia
[2] Higher Institute for Water Affairs, Al-Ajeelat, Q969+69J, Al Ajaylat, Libya

ARTICLE INFO

Article history:
Received 27 November 2024
Received in revised form 15 December 2024
Accepted 20 December 2024
Available online 25 December 2024

Keywords:
Prediction; bifacial PV modules; cell temperature; solar irradiance; bifacial gain; energy efficiency

ABSTRACT

The increasing global demand for renewable energy underscores the significance of photovoltaic (PV) technology as a sustainable energy source. Bifacial PV modules, unlike traditional monofacial modules, capture sunlight on both their front and rear surfaces, enhancing their efficiency. However, accurately estimating the energy output of PV panels remains challenging due to environmental influences. PV panels can only deliver power up to their rated capacity under Standard Test Conditions (STC), and deviations in weather conditions often lead to performance below the rated output. Accurate prediction, therefore, requires accounting for factors such as weather variations, peak sun hours, and temperature, which significantly affect performance. This study focuses on predicting the output of bifacial PV modules based on cell temperature and irradiance levels, aiming to achieve precise energy estimation. The analysis employs the JKM560N-72HL4-BCV module, with a maximum power rating of 560 W, to develop a predictive model incorporating environmental parameters. The research was conducted at the Faculty of Electrical and Electronic Engineering, Universiti Tun Hussein Onn Malaysia, Block QB, located at coordinates 1.861709, 103.085467. The result shows with a 25% effect of Bifacial Gain, the monthly bifacial PV power output shows a notable increase compared to the zero BG scenario, with February recording the highest output (260.87 W) and August the lowest (225.86 W).

1. Introduction

The convolution of fossil fuels as primary energy sources has indeed contributed significantly to global energy needs for decades and the global energy demand is increasing due to population growth and industrialization [1,2], but this reliance has come at a considerable environmental cost. Coal, natural gas and large hydro have been the main sources of power generation in Malaysia [3-5],

* *Corresponding author.*
E-mail address: nrsyazani25@gmail.com, afateh@uthm.edu.my

https://doi.org/10.37934/feel.1.1.921

and the combustion of coal, oil, and natural gas releases large amounts of carbon dioxide (CO_2) into the atmosphere, intensifying the greenhouse effect [6]. This effect traps heat, leading to global warming, which in turn accelerates climate change. Although energy can come from various sources, most of the current energy supply still relies on fossil fuels. This steady supply of fossil fuels is expected to be disrupted soon [7]. Given the environmental impact of fossils fuels and their limited availability, there is an urgent need to transition to cleaner, renewable energy sources.

Renewable energy sources are natural and sustainable, replenishing themselves over time. In Malaysia, the renewable energy landscape is advancing, with solar, hydro, and bioenergy leading efforts toward sustainability. One of the advantages of PV energy is that it has the least negative impact on the environment compared to any other energy sources [8-10]. These resources are becoming increasingly popular for their potential to boost electricity production efficiency [11]. Although this energy is already popular, but this energy is not fully utilized in society due to several factors. Renewable energy technologies contribute to sustainable development by reducing dependence on fossil fuels and potentially lessening the impacts of climate change [12,13].

One such promising solution is solar energy, a sustainable and abundant resource [14]. Bifacial PV modules are the optimal solution for addressing global energy challenges. Bifacial PV modules represent an innovative solution that is not yet widely adopted but offer significant advantages over conventional solar panels, providing greater efficiency and benefits to users. Bifacial PV modules can produce extra energy by harnessing solar energy from both sides of the module, making them an effective option for lowering the cost of photovoltaic power generation [15,16]. However, the performance of bifacial PV modules depends heavily on environmental conditions, and their power output varies with factors such as weather, location, and time. Under Standard Test Conditions (STC), the PV panels are designed to operate at their rated capacity. When actual conditions deviate from STC, the output may not match the rated capacity. In such cases, accurate solar power generation predictions require computational methods [17] that incorporate key elements like weather conditions, sun hours, and temperature, all of which play a critical role in determining performance. This study addresses the gap in accurate prediction models tailored for bifacial PV panels in tropical climates, particularly Malaysia.

2. Literature Review

2.1 Photovoltaic Panel (PV)

A photovoltaic (PV) panel, also known as a solar panel, is a device that converts sunlight into electrical energy. A single PV device is known as a cell but most of it is connected in series and parallel or in chain to form larger units known as modules to boost the power output of PV modules. These cells are usually encased within a glass layer and a plastic sheet, collectively forming what is typically recognized as panel [18]. When sunlight strikes the cell, it produces electricity energy, but the power output is dependent on the amount of sunlight supplied. The installation of the PV system involves several components which are solar panel, battery, inverter and mounting structures to secure the panels. These mechanical structures are designed to hold the solar panels at the best angle, helping them work efficiently throughout the day [19].

2.2 Bifacial PV Modules

The commonly known type of solar panel is the traditional one, Bifacial PV has emerged as the de-facto choice for utility-scale ground-mounted PV arrays due to their ability to collect solar irradiance from both the front and rear surfaces. The operating concept is like monofacial panels, but bifacial PV modules can also collect sunlight through their rear surface, in addition to the standard absorption through the front. This increase in generation from the rear side of a bifacial module is influenced by the albedo, the installation height of the solar module, the ground cover ratio (GCR), and diffuse horizontal irradiance (DHI) [20].

2.3 Electrical Performance of PV Panel

The electrical output of PV modules when installed at site may be different from those stated in the module datasheet. In the field, the PV modules are said to experience real operating conditions (ROC) which differ from standard test conditions (STC). STC rated for PV Panel is at 1000W/m2 of solar irradiance, 25 degrees Celsius of cell temperature and the solar spectrum is AM 1.5 [21]. The temperature of the cell environment needs to be considered. According to data in Malaysia, the average temperature ranges between 25°C and 28°C, while the average solar irradiance is between 400 W/m² and 600 W/m². Therefore, both parameters play a crucial role in achieving optimal power output and high efficiency.

3. Methodology

3.1 Location

To conduct this research, the location needs to be determined to obtain optimal and accurate results. Therefore, this study will be carried out at the Faculty of Electrical and Electronic Engineering (FKEE), Universiti Tun Hussein Onn Malaysia, Block QB, located at coordinates 1.861709, 103.085467 as illustrated in Fig 1. Since this research focuses on Bifacial PV modules, it will be conducted at the parking lot area of the faculty to gather output power readings with higher efficiency. This location was selected due to certain factors that influence the absorption rate of solar irradiance, which plays a crucial role in the performance of bifacial PV modules. The parking lot is expected to provide a suitable environment for capturing solar energy from both the front and rear sides of the module, improving energy output efficiency. Key factors like the surface reflectivity, tilt angle, and exposure to sunlight at different times of the day will contribute to the overall performance of the modules. This location provides an opportunity to assess the bifacial PV modules' ability to harness solar energy from both sides under real-world conditions. By selecting this environment, the research will gather valuable data to evaluate the benefits of bifacial technology compared to traditional monofacial modules. These conditions are crucial for obtaining accurate and efficient results for predicting the energy power output of Bifacial PV modules.

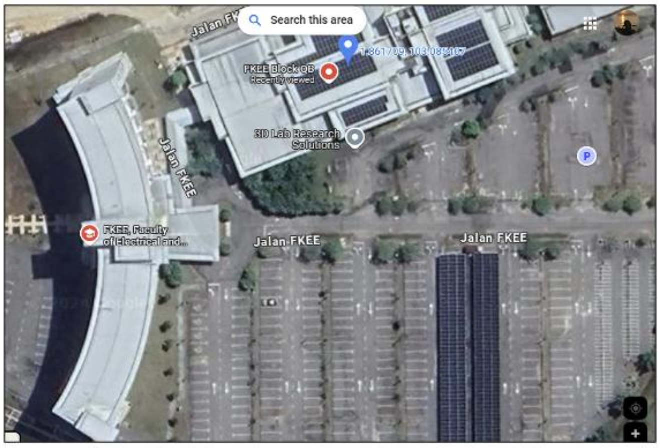


Fig. 1 Location of block QB FKEE, UTHM

2.2 Environmental Data

In this research, to obtain the accurate and reliable data output from bifacial photovoltaic (PV) modules, it is essential to collect environmental data, including cell temperature and solar irradiance. These two factors have a significant impact on the performance of PV modules, particularly bifacial ones, which rely on both direct and reflected sunlight to generate energy. The temperature data for Batu Pahat was collected from AccuWeather [22], a reliable and widely recognized online weather forecasting platform known for its accurate weather forecasts and warnings worldwide. The data spans the period from January 2024 to October 2024, representing average annual temperatures for this timeframe. These temperature values are utilized as one of the critical inputs for predicting rooftop photovoltaic (PV) power generation.

In addition to ambient temperature data, the analysis also considers the PV cell temperature, which significantly impacts the module's performance. The rated cell temperature used in this study is 20°C. The average temperature values, as presented in Table 1, include both the ambient temperature and the calculated cell temperature. This comprehensive dataset ensures accurate modelling and enhances the reliability of the predictive analysis for rooftop PV power generation.

2.2 Environmental Data

In this research, to obtain the accurate and reliable data output from bifacial photovoltaic (PV) modules, it is essential to collect environmental data, including cell temperature and solar irradiance. These two factors have a significant impact on the performance of PV modules, particularly bifacial ones, which rely on both direct and reflected sunlight to generate energy. The temperature data for Batu Pahat was collected from AccuWeather [22], a reliable and widely recognized online weather forecasting platform known for its accurate weather forecasts and warnings worldwide. The data spans the period from January 2024 to October 2024, representing average annual temperatures for this timeframe. These temperature values are utilized as one of the critical inputs for predicting rooftop photovoltaic (PV) power generation.

In addition to ambient temperature data, the analysis also considers the PV cell temperature, which significantly impacts the module's performance. The rated cell temperature used in this study is 20°C. The average temperature values, as presented in Table 1, include both the ambient temperature and the calculated cell temperature. This comprehensive dataset ensures accurate modelling and enhances the reliability of the predictive analysis for rooftop PV power generation.

Table 1
Average cell temperature data in Parit Raja,Batu Pahat (January 2024 – October 2024)

Month	Cell temperature (°C)
January	50
February	54
March	50
April	52
Mei	51
June	50
July	50
August	53
September	51
October	52

Next, the solar irradiance data used in this study was obtained from RET Screen Expert [23], a comprehensive software tool widely used for energy analysis and renewable energy project evaluation. This data represents the average solar irradiance levels in the Parit Raja area, Batu Pahat, and is essential for accurately predicting photovoltaic (PV) power generation.

The solar irradiance values, as shown in Table 2, provide detailed information about the solar energy potential in the study location. These values are critical for modelling the energy output of bifacial PV modules, as they directly impact the amount of sunlight available for energy conversion. By combining this solar irradiance data with other inputs, such as temperature, the study ensures a robust and precise prediction of PV power generation in the region.

Table 2
Solar irradiance data in Parit Raja, Batu Pahat (January 2024 - October 2024)

Month	Solar irradiance (kW/m2/d)
January	4.57
February	5.18
March	5.04
April	4.87
Mei	4.60
June	4.57
July	4.49
August	4.47
September	4.65
October	4.65

2.3 Bifacial Data

Apart from environmental data such as temperature and solar irradiance, bifacial photovoltaic (PV) panel data is crucial for accurately determining the actual power output of the system. This includes detailed technical specifications obtained from the datasheet of the bifacial PV module used in this study, sourced from the JinkoSolar website, as illustrated in Table 3. The module selected for analysis has a rated power output of 560 Watts and the design is shown in Figure 2.

The bifacial data includes parameters such as the front and rear efficiency of the panels, the albedo effect (ground reflectivity), and the *Bifacial Gain* (BG), which quantifies the additional energy contribution from the rear side of the panels. For this analysis, two scenarios are considered, the *zero effect of BG*, which assumes no additional rear-side energy contribution, and a *25% BG effect*, representing a realistic enhancement in energy generation due to reflected sunlight. By integrating these bifacial parameters with environmental data, the study ensures a comprehensive and accurate analysis of the energy output potential of the 560W bifacial PV module under actual conditions, leading to reliable performance predictions.

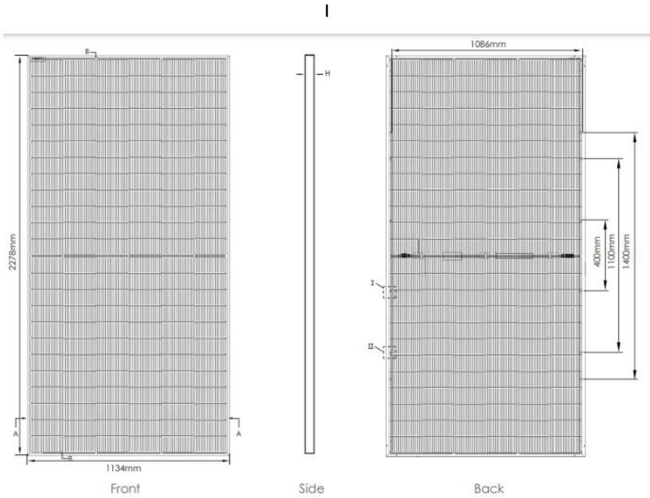


Fig. 2. The bifacial PV solar panel 560W

Table 3
Technical specifications of bifacial PV modules (560W) from JinkoSolar

Module Type	JKM560N-72HL4-BCV
Maximum power (Pma)	560W
Maximum power voltage (Vmp)	41.95V
Maximum power current (Imp)	13.35A
Module efficiency STC (%)	21.68%
Operating temperature (°C)	-40°C~+85°C
Power tolerance	0~+3%
Temperature coefficients of Pmax	-0.30%/°C
Nominal operating cell temperature (NCOT)	45±2°C
Refer. Bifacial factor	80±
1st year degradation	1.5%
Subsequent year	0.40%

Table 4
Bifacial Gain (BG) effect of bifacial PV modules at 5%, 15%, and 25% BG values

Bifacial gain (%)	Maximum power (W)	Module efficiency STC (%)
5	588	22.77
15	644	24.93
25	700	27.10

Table 4 presents the datasheet for the Bifacial Gain (BG) effect of the bifacial photovoltaic (PV) modules, detailing the potential increase in energy generation from the rear side of the panels. The BG values of 5%, 15%, and 25% illustrate how varying levels of sunlight reflection from the surrounding environment, such as the ground surface (albedo) or nearby structures, can enhance the overall performance of the bifacial modules.

The BG effect represents the additional energy output achieved by capturing reflected sunlight on the rear surface of the module. In this table, the 5% BG effect assumes a minimal contribution from the rear side, indicating that only a small portion of reflected sunlight is utilized for energy generation. A 15% BG effect represents a moderate enhancement, where the rear side contributes a more noticeable amount of energy. Lastly, the 25% BG effect represents a high level of reflected sunlight being captured, typically observed in environments with high albedo.

These varying BG values provide insight into the different levels of energy output improvement that can be achieved depending on the environmental conditions and module placement. The higher the BG effect, the greater the additional energy gain from the rear side of the panel, thereby increasing the total energy generation potential of the system.

By incorporating these BG effects into energy generation models, the data in Table 4 allows for a more accurate prediction of the performance of bifacial PV modules in specific locations. It helps in assessing the actual energy output under different environmental scenarios, such as varying ground reflectivity, installation tilt angles, and shading effects. This detailed understanding of bifacial gain is essential for optimizing the design and efficiency of PV systems, particularly in areas with favourable conditions for bifacial energy capture.

2.4 Equation for the Output Power

In this study, to manually calculate the power output of a photovoltaic (PV) system, several factors must be considered, including the environmental data such as the ambient temperature and solar irradiance of the area. These environmental conditions are essential when predicting the power output, as they directly impact the performance of the PV modules. The cell temperature must be estimated in the first step using Eq. (1) [21] while the derating factor related to the temperature impact is then determined using Eq. (2) [21]. The output power can be calculated using the equation for maximum power output (Pmax) as in Eq. (3) [21], incorporates various parameters such as degradation factor (fdegrade) as in Eq. (4) [21], bifacial gain factor (fg) as in Eq. (5) [21]. These factors are derived from the data presented in Table 3, with each one playing a vital role in adjusting the theoretical maximum power output to reflect real-world conditions. The equation for maximum power output (Pmax) is typically expressed as:

$$T_x = T_{amb} + (G_i \times (NOCT - 20°C))/(800 W/m2) \tag{1}$$

Where,
Tamb is ambient temperature (°C)
NOCT us Nominal Operating Cell Temperature (°C)
Derating factor of power due to cell temperature effect,

$$f_{temp\_p} = 1 + [(\alpha/(100\%)) \times (T_{cell} - T_{STC})] \tag{2}$$

Thus, power output for Real Operating Condition (ROC) is

$$P_{max} = P_{max}(STC) \times f_{mm} \times f_{degrad} \times f_{temp\_p} \times f_g \times f_{clean} \times f_{unshade} \tag{3}$$

Derating factor of power due to LID and aging effect,

$$f_{degrade} = 1 - [(\text{1st annual degrade} - \text{subsequent year})/100] \tag{4}$$

$$\text{Peak sun factor, } f_g = G/1000 \tag{5}$$

Where,
α is temperature coefficient of power (% per °C)
T_STC is temperature at Standard Test Condition (STC)
Fdegrade is the total de-rating factors related to power

Fmm	is a de-rating factor due to module mismatch of power [21]
Fg	is the peak sun factor [21]
Fdirt	is a de-rating factor due to dirt [21]
Fage	is a de-rating factor due to aging [21]

$$\text{Power gain} = \left(\frac{P_b - P_a}{P_a}\right) \times 100\% \tag{6}$$

Where,
P_b is the maximum power output with 25% of bifacial gain
P_a is the maximum power output with 0 of bifacial gain

The temperature of the surroundings and solar irradiance are crucial factors in determining the output power of a PV panel. In addition to these, derating factors must also be considered to improve the accuracy of the power prediction. These factors account for real-world conditions that can affect the performance of the PV panels over time, such as temperature variations, module degradation, and environmental influences. For this case, to obtain a comparison between the power output with zero effect of Bifacial Gain and the power output with a 25% effect of Bifacial Gain, manual calculations using Eq. (6) are required. This equation incorporates the necessary parameters to accurately determine the impact of Bifacial Gain on the total power output, allowing for a detailed analysis of the performance difference under both conditions.

3. Results and discussion

3.1 Total of Monthly Bifacial PV Power Output with Zero Effect of Bifacial Gain

The results below represent the Total Monthly Bifacial PV Power Output with zero effect of Bifacial Gain, as illustrated in Table 5 and the statistic of the result shown in Fig 3. These values reflect the energy generated solely from the front side of the bifacial PV module, without considering any additional contribution from the rear side. The power output is directly influenced by the solar irradiance received each month, as well as other environmental factors such as temperature and weather conditions. This data provides a baseline for comparing the performance of the PV system under standard conditions, highlighting the impact of direct solar exposure without the benefits of rear-side reflected irradiance.

Table 1
Power output with zero effect of bifacial gain

Month	Power Output (W)
January	186.57
February	208.69
March	205.77
April	197.51
Mei	187.18
June	186.58
July	183.31
August	180.69
September	189.22
October	188.59

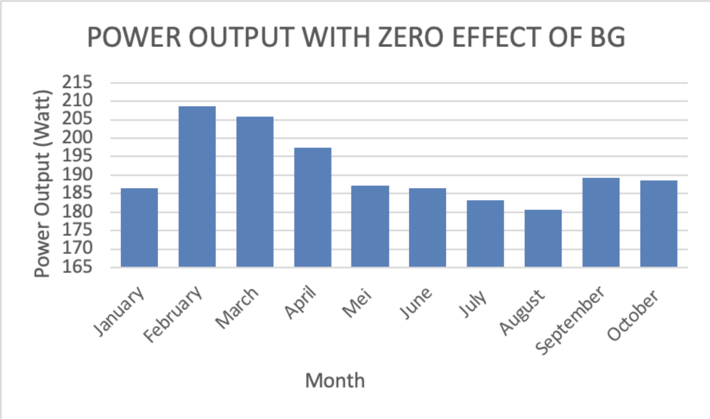


Fig. 3. Statistic of power output with zero effect of bifacial gain

The monthly bifacial PV power output with zero effect of Bifacial Gain highlights the direct relationship between solar irradiance and power output. February records the highest power output (208.69 W), which corresponds to higher solar irradiance during this period, while August shows the lowest output (180.69 W), likely due to reduced solar irradiance. The output variations across the months reflect changes in environmental conditions, such as cloud cover and seasonal irradiance levels. Without the contribution of rear-side reflection, the PV module's performance depends entirely on the direct solar irradiance received, which explains the observed fluctuation in power generation.

3.2 Total of Monthly Bifacial PV Power Output with 25% effect of Bifacial Gain

The results below represent the Total Monthly Bifacial PV Power Output with a 25% effect of Bifacial Gain, as shown in Table 6 and the statistic of the result shown in Fig.4. These values include the additional energy generated from the rear side of the bifacial PV module due to reflected sunlight. The power output is influenced by both direct solar irradiance and the gain from the rear side, highlighting the improved performance of the PV system with 25% Bifacial Gain.

Table 6
Power output with 25% effect of bifacial gain

Month	Power Output (W)
January	233.22
February	260.87
March	257.21
April	246.89
Mei	233.98
June	233.22
July	229.14
August	225.86
September	236.52
October	235.74

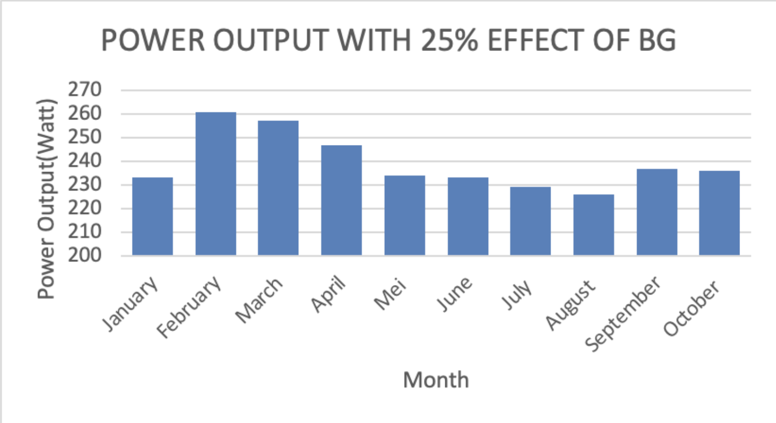


Fig. 4. Statistic of power output with zero effect of bifacial gain

With a 25% effect of Bifacial Gain, the monthly bifacial PV power output shows a notable increase compared to the zero BG scenario, demonstrating the significant contribution of reflected solar irradiance captured by the rear side of the panels. February again records the highest output (260.87 W), aligning with high solar irradiance during this month, while August, with lower irradiance, produces the lowest output (225.86 W). The 25% BG effect amplifies the output, reflecting how bifacial panels leverage both direct and reflected irradiance to enhance energy generation. This relationship underscores the importance of high albedo surfaces and optimal panel placement in maximizing bifacial panel performance. The consistent increase in power output across all months highlights the effectiveness of bifacial technology in improving energy generation, especially in conditions where reflected sunlight is substantial.

3.3 Power Gain

The power gain refers to the additional energy generated by the rear side of the bifacial PV module, which captures reflected sunlight from the ground or surrounding surfaces. This gain increases the total power output of the system beyond the energy generated by the front side alone. The extent of this power gain depends on factors such as the albedo (reflectivity) of the surface, the tilt of the panels, and the amount of sunlight that reaches the rear side. With a 25% Bifacial Gain, the rear side contributes 25% more energy, improving the overall efficiency and power generation of the bifacial PV system. The result of the power gain is shown in Table 7, with the statistical results illustrated in Figure 5.

Table 7
Power Gain (January 2024 - October 2024)

Month	Power Gain (W)
January	25.00402
February	25.00359
March	24.99879
April	25.00127
Mei	25.00267
June	24.99732
July	25.00136
August	24.99862
September	24.99736
October	25.00133

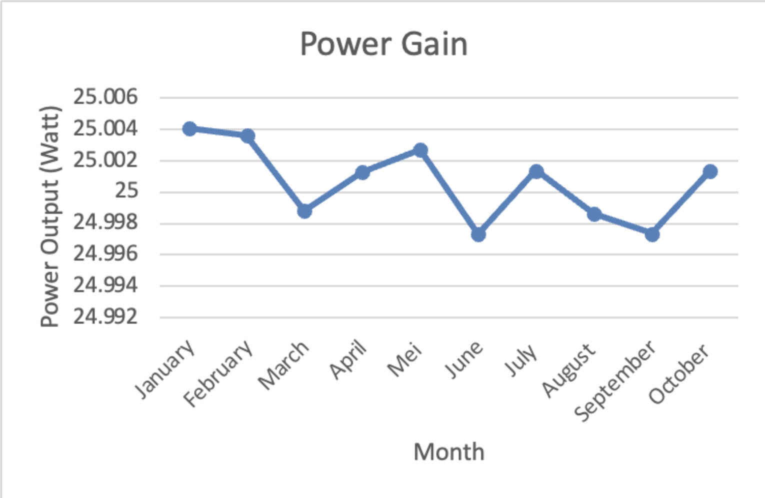


Fig. 5. Statistic of power gain (January 2024 - October 2024)

The results of the power gain from January 2024 to October 2024 demonstrate a significant improvement in the total energy output of the bifacial PV modules due to the 25% Bifacial Gain. The rear side of the modules, capturing reflected sunlight, contributes an additional 25% of power, enhancing the overall performance of the system. This increase in power generation is particularly notable when compared to systems with no Bifacial Gain. The data highlights the potential of bifacial technology to optimize energy production, especially in environments with high albedo surfaces, ensuring more efficient use of available solar resources.

The findings demonstrate the enhanced performance of bifacial PV panels compared to monofacial panels, particularly under conditions with significant rear-side reflectivity. The results align with previous studies, such as in the previous study [15], which highlight the role of albedo and bifacial efficiency in optimizing energy output. However, unlike these studies conducted in temperate climates, our research provides novel insights into bifacial panel performance under tropical conditions with moderate irradiance and high temperatures.

While bifacial PV panels demonstrate enhanced efficiency, their environmental implications must be considered. The production of bifacial modules involves higher material use for dual-sided functionality, potentially increasing their carbon footprint compared to monofacial panels. However, the longer lifespan and increased energy output offset these initial impacts, resulting in a lower lifecycle carbon intensity. Additionally, advancements in recycling technologies for PV materials can further mitigate environmental concerns.

4.Conclusions

In conclusion, this research highlights the importance of several key parameters in accurately predicting the power output of bifacial PV modules, including solar irradiance, ambient temperature, Bifacial Gain, and environmental factors such as shading, module orientation, and cleanliness. These parameters, along with temperature and degradation corrections, ensure a precise calculation of the actual power output of bifacial modules in real-world conditions. By considering both the front and rear sides of the panels, bifacial PV technology significantly enhances energy generation, offering greater efficiency than traditional monofacial panels. The advantages of using bifacial PV modules lie in their ability to capture reflected sunlight from the rear side, increasing overall power output, particularly in environments with high albedo surfaces. The dual benefit of its low-cost nature and bifacial performance gain multiplies the value proposition of tensegrity structure as a solar PV racking solution [24]. This technology not only reduces the area needed for installation but also improves the return on investment over time. As demand for renewable energy grows, bifacial modules will become increasingly valuable for residential, commercial, and large-scale solar applications, especially in regions with reflective surfaces. With continued advancements, bifacial PV panels will play a key role in the future of solar energy, optimizing efficiency and sustainability. A suggestion for future work is to conduct experiments under varying albedo levels to explore bifacial gain under different ground conditions. This would provide deeper insights into how surface reflectivity impacts energy output and optimize the placement of bifacial PV modules in diverse environments. Further studies could also investigate the integration of advanced machine learning techniques to improve the accuracy of predictive models by incorporating more dynamic environmental variables. Additionally, expanding the data collection to include multiple locations with diverse climatic conditions. Such efforts would allow for a more comprehensive analysis of bifacial panel performance across varying irradiance levels, temperatures, and albedo effects.

Acknowledgement
This research was supported by the Ministry of Higher Education (MOHE) through the Early Career Fundamental Research Grant Scheme (FRGS-EC) under the project code FRGS-EC/1/2024/TK08/UTHM/02/9 (UTHM Code K561). The authors would like to express their heartfelt gratitude to UTHM for providing an excellent research platform.

References
[1] Emezirinwune, Michael Uzoamaka, Isaiah Adediji Adejumobi, Oluwaseun Ibrahim Adebisi, and Festus Gboyega Akinboro. "Synergizing hybrid renewable energy systems and sustainable agriculture for rural development in Nigeria." *e-Prime-Advances in Electrical Engineering, Electronics and Energy* 7 (2024): 100492. https://doi.org/10.1016/j.prime.2024.100492

[2] Riva, Fabio, Helene Ahlborg, Elias Hartvigsson, Shonali Pachauri, and Emanuela Colombo. "Electricity access and rural development: Review of complex socio-economic dynamics and causal diagrams for more appropriate energy modelling." *Energy for sustainable development* 43 (2018): 203-223. https://doi.org/10.1016/j.esd.2018.02.003

[3] Sharvini, Siva Raman, Zainura Zainon Noor, Chun Shiong Chong, Lindsay C. Stringer, and Rafiu Olasunkanmi Yusuf. "Energy consumption trends and their linkages with renewable energy policies in East and Southeast Asian countries: Challenges and opportunities." *Sustainable Environment Research* 28, no. 6 (2018): 257-266. https://doi.org/10.1016/j.serj.2018.08.006

[4] Ashnani, Mohammad Hossein Mohammadi, Anwar Johari, Haslenda Hashim, and Elham Hasani. "A source of renewable energy in Malaysia, why biodiesel?." *Renewable and Sustainable Energy Reviews* 35 (2014): 244-257. https://doi.org/10.1016/j.rser.2014.04.001

[5] Ilham, Zul. "Multi-criteria decision analysis for evaluation of potential renewable energy resources in Malaysia." *Progress in Energy and Environment* 21 (2022): 8-18. https://doi.org/10.37934/progee.21.1.818

[6] Wang, Zhengshi, Yuyin Li, Anguo Wang, You Wu, Tao Han, and Yao Ge. "Photovoltaic Power Generation Prediction Based on In-Depth Learning for Smart Grid." In *2023 32nd Wireless and Optical Communications Conference (WOCC)*, pp. 1-6. IEEE, 2023. https://doi.org/10.1109/WOCC58016.2023.10139371

[7] Mahadzir, Cempaka Amalin, Ahmad Fateh Mohamad Nor, Siti Amely Jumaat, and Noor Syahirah Ahmad Safawi. 2023. "Prediction of the Optimum Photovoltaic Output Based on Cell Temperature and Solar Irradiance." ARPN Journal of Engineering and Applied Sciences 18 (24): 2666–2670. https://doi.org/10.59018/1223318

[8] Du, Liufeng, Linghua Zhang, and Xiyan Tian. "Deep power forecasting model for building attached photovoltaic system." *IEEE Access* 6 (2018): 52639-52651. https://doi.org/10.1109/ACCESS.2018.2869424

[9] El-Shahat, Adel, Rami J. Haddad, Bikiran Guha, and Youakim Kalaani. "Sizing residential photovoltaic systems in the state of Georgia." In *2015 IEEE International Conference on Smart Grid Communications (SmartGridComm)*, pp. 629-634. IEEE, 2015. https://doi.org/10.1109/SmartGridComm.2015.7436371

[10] Wee, Yun Nee, and Ahmad Fateh Mohamad Nor. "Prediction of Rooftop Photovoltaic Power Generation Using Artificial Neural Network." In *2020 IEEE Student Conference on Research and Development (SCOReD)*, pp. 346-351. IEEE, 2020. https://doi.org/10.1109/SCOReD50371.2020.9250952

[11] Sulaiman, Nabila, Sany Izan Ihsan, Syed Noh Syed Abu Bakar, Zafri Azran Abdul Majid, and Zairul Azrul Zakaria. "Evacuated tubes solar air collectors: A review on design configurations, simulation works and applications." *Progress in Energy and Environment* (2023): 10-32. https://doi.org/10.37934/progee.25.1.1032

[12] Azman, A. Y., A. A. Rahman, N. A. Bakar, F. Hanaffi, and A. Khamis. "Study of renewable energy potential in Malaysia." In *2011 IEEE Conference on Clean Energy and Technology (CET)*, pp. 170-176. IEEE, 2011. https://doi.org/10.1109/CET.2011.6041458 .

[13] Zaharim, Azami, Sohif Mat, Kamaruzzaman Sopian, Alias Jedi, Muhammad Aslam Mohd Safari, Nurulkamal Masseran, and Azman Bin Abdul Rahim. "Public acceptance on stand-alone renewable energy project in rural area of Malaysia." In *2017 International Conference in Energy and Sustainability in Small Developing Economies (ES2DE)*, pp. 1-7. IEEE, 2017. https://doi.org/10.1109/ES2DE.2017.8015349

[14] Al Smin, Ahmed Moh A., Alkbir Munir Faraj Almabrouk, Sairul Izwan Safie, Mohd Al Fatihhi Mohd Szali Januddi, Mohd Fahmi Hussin, and Abdulgader Alsharif. "Enhancing solar hybrid system efficiency in Libya through PSO & flower pollination optimization." *Progress in Energy and Environment* (2024): 23-31. https://doi.org/10.37934/progee.27.1.2331

[15] Ghenai, Chaouki, Fahad Faraz Ahmad, Oussama Rejeb, and Abdul Kadir Hamid. "Sensitivity analysis of design parameters and power gain correlations of bi-facial solar PV system using response surface methodology." *Solar Energy* 223 (2021): 44-53. https://doi.org/10.1016/j.solener.2021.05.024

[16] Mahadzir, Cempaka Amalin, Ahmad Fateh Mohamad Nor, and Siti Amely Jumaat. "Photovoltaic Power Output Prediction using Graphical User Interface and Artificial Neural Network." *Majlesi Journal of Electrical Engineering* 17, no. 4 (2023).https://doi.org/10.30486/mjee.2023.1995210.1243

[17] Cheng, Tan, Xu Yichuan, Liu Hui, and Gu Jie. "Comparison Method for Photovoltaic Power Prediction Effect Based on LSTM in Multiple Scenarios." In *2023 4th International Conference on Advanced Electrical and Energy Systems (AEES)*, pp. 743-479. IEEE, 2023. https://doi.org/10.1109/AEES59800.2023.10469307

[18] Eke, Mkpamdi N. "Photovoltaic Characteristics and Applications." In *Electrode Materials for Energy Storage and Conversion*, pp. 351-364. CRC Press, 2021. https://doi.org/10.1201/9781003145585

[19] Rosu, Petru Valentin, Adrian-Traian Plesca, Georgel Gabor, and Gabriel Chiriac. "Optimizing the operation of photovoltaic panel systems." In *2020 International Conference and Exposition on Electrical And Power Engineering (EPE)*, pp. 318-321. IEEE, 2020. https://doi.org/10.1109/EPE50722.2020.9305534

[20] Takoorparsadh, Mohini, and Arnold J. Rix. "Bifacial PV Performance Evaluation with reference to the Solar Spectrum and Broadband Irradiance." In *2023 3rd International Conference on Electrical, Computer, Communications and Mechatronics Engineering (ICECCME)*, pp. 1-7. IEEE, 2023.https://doi.org/10.1109/ICECCME57830.2023.10252838

[21] Shaari, Sulaiman, Ahmad Maliki Omar, Nor Zaini Ikrom Zakaria, Hedzlin Zainuddin, and Shahril Irwan Sulaiman. 2022. Sustainable Energy Development Authority (SEDA) Malaysia. Putrajaya, Malaysia: Sustainable Energy Development Authority. ISBN: 978-967-12390-7-0

[22] Batu Pahat Weather. 2020. "Batu Pahat Weather." June. https://www.accuweather.com

[23] Natural Resources Canada. 2022. RETScreen Expert Software. Government of Canada. https://www.nrcan.gc.ca/maps-tools-and-publications/tools/retscreen/7465

[24] Arefeen, Shamsul, and Tim Dallas. "Potential of tensegrity racking structures for enhanced bifacial PV array performance." *Solar Energy* 269 (2024): 112344. https://doi.org/10.1016/j.solener.2024.112344